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Abstract

The size of the Ga-Mampa wetland (1 km^2), in the Olifants River catchment in South Africa, was halved between 1996 and 2004. This jeopardizes the ecological integrity and influences the benefits people obtain from the wetland. This study therefore analysed the economic values of the provisioning services derived from the Ga-Mampa wetland and evaluated their contribution to the livelihoods of local stakeholders. Using a direct market valuation technique and based on a mix of data collection approaches that include questionnaire survey, focus group discussions, key informant interviews, field observation and measurements and collection of market prices, we estimated the economic value of the main provisioning services provided by the wetland (collection of edible plants, crop production, livestock grazing, fishing, hunting, fuel-wood, reeds and sedge collection). The results show that the contribution of the wetland to the livelihoods of local community, estimated at an annual net financial value of $211 per household, far exceeds its annual cash income of $35 per household and is about half of the average monthly cash income from all income sources. Crop production contributes the highest gross and net financial value, whereas sedge collection yields the highest cash income.

Most of the materials harvested from the wetland are used for household subsistence and are rarely sold. In addition to their economic and livelihood value, the wetland services are also essential to sustain the social and cultural responsibilities in gift giving to neighbours and relatives. The study concludes that the local people are highly dependent on the wetland ecosystem services in many ways but that current use exceeds sustainability levels, which jeopardizes their future livelihoods. We therefore recommend that the local stakeholders be supported in identifying alternative sources of livelihoods while simultaneously developing sustainable management strategies for small wetlands such as Ga-Mampa. In addition, other ecosystem services (regulating, supporting and cultural, including recreational benefits) provided by the wetland to local and downstream stakeholders need to be further studied and economically assessed.

Keywords: economic valuation; livelihood analysis; market valuation; provisioning services; wetland ecosystem.

1. Introduction

Since the very beginning of human life on earth, wetlands have provided valuable resources and refuge for human populations and many other life forms (Ramsar Convention Bureau, 2002). Through their ecological complexity, wetland areas perform many functions, which in turn provide the goods and services (hereafter called services, adopting the terminology of Millennium Ecosystem Assessment (2003)) that are important for human well-being (de Groot *et al.*, 2006). Specifically, wetlands in Southern Africa have been identified to support the livelihoods of many rural and often poor households (Turpie *et al.*, 1999; Turpie, 2000; Masiyandima *et al.*, 2004; McCartney and van Koppen, 2004; Masiyandima *et al.*, 2005). In spite of their importance in sustaining human well-being, many wetlands remain threatened.
The Ga-Mampa wetland is no exception and agricultural encroachment into the wetland has led to halving of its size between 1996 and 2004 (Sarron, 2005). This jeopardizes the ecological integrity and influences the benefits people obtain from the wetland.

Lack of readily available data and information about the values of wetlands was identified as a major reason why their conversion and development have been viewed as a generally more attractive option, most especially in developing countries (Balmford *et al.*, 2002; Mmopelwa, 2006). Even where such information is available, it is often for relatively large wetlands and there is less focus on understanding the economic values of smaller wetlands, probably, because they are considered insignificant. However, small-scale wetlands are extensively used for subsistence agriculture in Southern Africa, which might have a cumulative impact on their catchment hydrology. Thus, economic valuation of the direct use values of small wetlands improves awareness and is critical to planning for their sustainable management and wise use (Ramsar Convention Secretariat, 2004).

Noticing the importance of wetlands in livelihoods of rural people in Southern Africa, coupled with the lack of knowledge on the relationships between human uses and ecological processes taking place in wetlands in the area, The International Water Management Institute (IWMI) and its partners commissioned this study as a contribution to the project on "*Wetlands-based livelihoods in the Limpopo basin: balancing social welfare and environmental security*", under the Challenge Program on Water and Food (CPWF). The objectives of this study are to provide economic information about the provisioning services of Ga-Mampa wetland and evaluate the contribution(s) of these services to the livelihoods of local stakeholders.

The paper is organized as follows. In section 2, we describe the study site. Section 3 explains the key methods adopted in the study. Section 4 presents the result of the study. In section 5, we discuss the results in comparison with other studies. Section 6 summarises the main conclusions of this study.

2. Study site

Ga-Mampa valley is a rural area located in the Mafefe tribal area of the Lepelle-Nkumpi Local Municipality of the Republic of South Africa. The Ga-Mampa valley covers a land area of about 5km^2. Ga-Mampa wetland is a riverine wetland of the Mohlapitsi River, a tributary of the Olifants River. It is approximately 1km^2 with a catchment of

approximately 40,000 hectares (Kotze, 2005) (see Figure 1). There are two main villages in the valley: Ga-Mampa and Mantlhane. Each main village has a headman *(Induna*, traditional head of the people*)*, who is responsible for allocation of communal land among the community members and gives authorization for harvesting natural resources within the wetland. The people of Ga-Mampa have also formed for themselves a development forum (Ga-Mampa Community Development Forum - GCDF) responsible to formulate programmes for the development of the area and bring them to the local municipality. Population of the valley, mainly composed of Pedi speaking people was estimated at 2758 inhabitants in 394 households as at October 2006.

Ga-Mampa valley experiences a semi-arid climate with seasonal rainfall that largely occurs during the summer months, from October to April (mean annual rainfall of 570mm), and long dry periods from May to September. Average temperature is highest between January and December, and lowest between June and July. The Ga-Mampa wetland supports a range of different vegetation types, which vary according to particular site characteristics including wetness of area, location relative to river channel. Reed (*Phragmites mauritianus)* is the most widely occurring plant species in the wetland, with small isolated strands of sedges (*Cyperus latifolis* and *Cyperus sexangularis)* (Kotze, 2005). Both species are used by the local population for building and crafting purposes.

The valley is surrounded by nature reserves of which the local population uses natural resources for their livelihoods (fuel wood, grazing lands, hunting area, wild plant collection), although it is not legally authorized. Three small-scale irrigation schemes built in 1959 by the former homeland government used to contribute to a large part of the local food production. After the withdrawal of government support in the mid-nineties and the 1995 and 2000 floods, the infrastructure has deteriorated and large parts of the schemes are no longer in use. Following the collapse of irrigation schemes, and attracted by wetland wetness and rich soils, farmers have converted half of its area to agriculture over the last decade.

3. Method

Methodological framework

The framework (Figure 2) adopted in this study is based both on integrated environmental assessment frameworks developed by De Groot *et al.*, 2002 and the Millennium Ecosystem Assessment, 2003. The comprehensive assessment of benefits (services) derived from ecosystems comprises two steps: *ecosystem function analysis* and *economic valuation of the associated goods and services*.

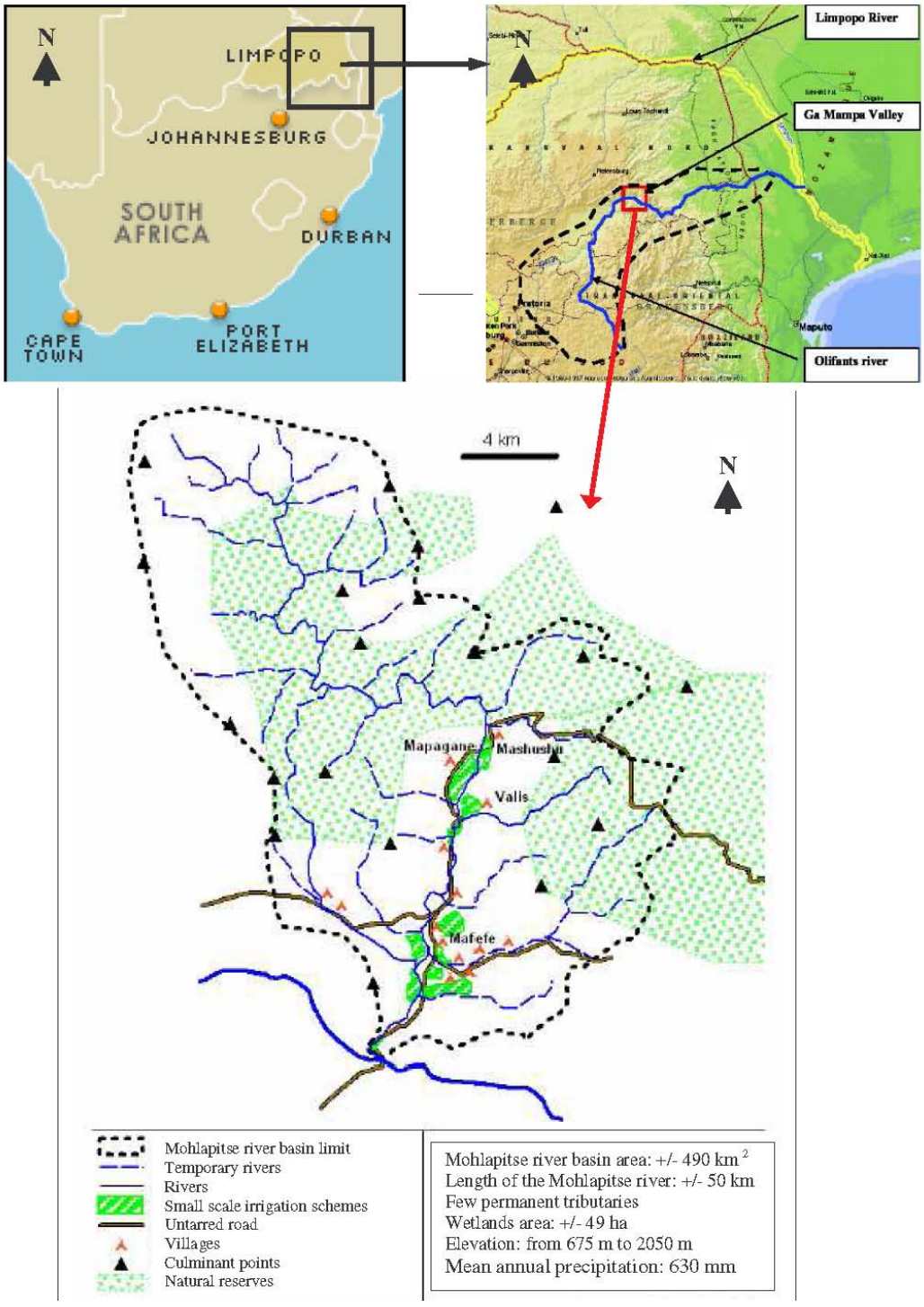
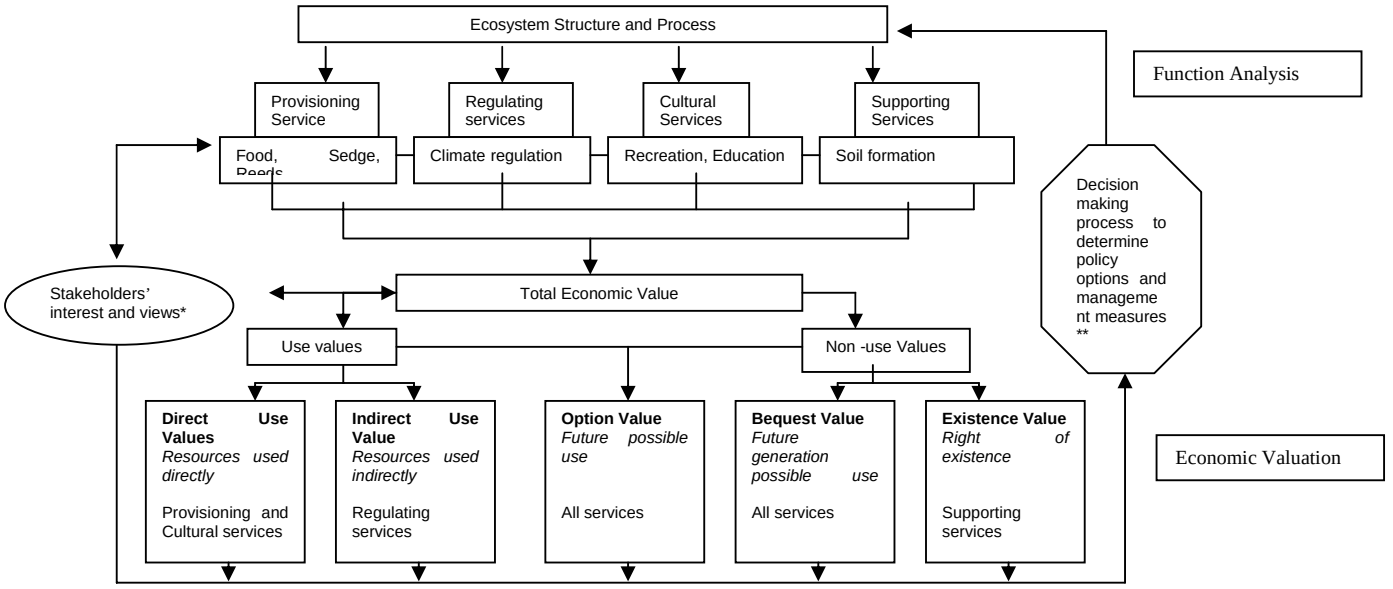


Figure 1: Location of the Ga-Mampa valley in the Olifants River Catchment (Source Chiron 2005)



*Stakeholders interest and views should be considered in most steps of the assessment.
** Tools such as cost benefit analysis, trade-off analysis; multi-criteria analysis are used in support of the decision making process.

Figure 2: Framework for integrated assessment and valuation of ecosystem services (Adapted from De Groot et al., 2002 and Millennium Ecosystem Assessment, 2003).

Ecosystem function analysis is the process by which a wide range of key elements of complex ecological structures and processes are translated into a more limited number of functions, which in turn provide goods and services (De Groot, 2006). This study adopts the typology and nomenclature of ecosystem services proposed by the Millennium Ecosystem Assessment, which classified them into provisioning, supporting, regulating and cultural services. In the case of Ga-Mampa wetland the services were identified on the basis of existing literature on the site (Darradi *et al.*, 2006 and Tinguery, 2006), discussions with stakeholders and field observation. *Economic valuation* is an attempt to assign quantitative values to market and non-market services provided by environmental resources (Barbier *et al.*, 1997). Among the various existing valuation techniques, the direct market valuation technique was adopted in this study because it makes the outcome comparable to other sources of income for the local population. In addition, a participatory ranking exercise of the importance of wetland services for the people livelihoods was performed using the Pebble Distribution Method, which is a common tool in Participatory Rural Appraisal used to get the perception of respondents on various issues. In our case, during a focus group discussion, participants were asked to allocate 25 stones among the various wetland services depending on their importance for their livelihoods (Sheil *et al.*, 2003).

Data collection

Data were collected using a combination of participatory and formal methods. A sample of 66 households out of the estimated total population of 394 households was interviewed face-to-face in October 2006 using a structured questionnaire. The sample was divided in two sub-samples: 33 wetland croppers (households cultivating one or

more plot in the wetland) were randomly selected among the 99 wetland farmers identified by the headmen of the two villages; 33 non-wetland croppers were selected randomly from the total population excluding wetland croppers (i.e., 295 households). The questionnaire was structured into three sections: the first one captured demographic and socio-economic characteristics of respondents; the second section dealt with general information about access and use of the wetland; and the third section asked detailed information on each provisioning service under study (quantity of service harvested, costs and price). Additional questions were administered to wetland croppers on their crop production.

These intensive interviews were complemented by group discussions and other participatory tools. A first focus group discussion was held at the beginning of the study to provide some background information, identify main uses and users of wetland resources and establish the list of wetland croppers. A second focus group discussion was conducted after completion of the household survey, to verify and complement information collected during the survey, for example on price variability, durability of implements used in wetland natural resources collection or cropping, and use of household labour. Equivalence between measurement units used by local people and standard units as well as travel time between homesteads and the wetland were estimated through direct field observation and measurements. Several key informants were also interviewed: the headman of Mantlhane (who provided information such as access to the wetland and number of households in his domain); the chairman and secretary of the GCDF (who gave general information including cultural and historical background); agricultural extension officer (about activities in the wetland and crop yield); ward councillor (future potential of the wetland for tourism); a farmer who could speak English (cropping activities, sale and use); and the wife to one of the traditional healers (on use of wetland plants for medicinal purpose). During the second focus group discussion, participants were asked to together rank wetland services in terms of their value for the community.

A visit to the local market in Ga-Mampa and Mafefe allowed estimating market prices, when they could not be ascertained through the household survey, group discussion or informant interviews. Finally a feedback workshop was organized for the local stakeholders to communicate the preliminary results of the study. The time for questions and comments proved to be an avenue to get some insights on issues such as pest control in the wetland.

Data analysis

Three indicators are used to express the monetary value of each wetland provisioning service: the Gross Financial Value (GFV), the Net Financial Value (NFV) and Cash Income (CI). Values were expressed by respondents in South African Rand (R), and were then converted into United States of American Dollars ($) based on an average exchange rate between September 2005 and September 2006 at R6.46 = $1. These values were computed as follows:

$$GFV = TQH \times P \qquad \textit{(Equation 1)}$$

where TQH is the Total annual Quantity Harvested (or produced) and P is the average price per unit of product at which a resource/commodity was sold in Ga-Mampa for the

period under consideration (September 2005 – October 2006). When the product was not marketed in Ga-Mampa, the price of the closest marketed substitute was used. TQH was computed from the average annual quantity collected per household, estimated from the sample, multiplied by the percentage of households participating in the activity (PPH), also estimated from the sample, and by the total number of households in the population:

$$TQH = \frac{\sum_{i=1}^{m} HC_i}{n} \times PHH \qquad \textit{(Equation 2)} \qquad \text{with} \qquad PHH = \frac{m}{n} \times N$$

where HC_i is the quantity of product collected by household i, m the number of households participating in the activity in the sample, n the total number of sampled households (n=66) and N the total number of households in the population (N=394).

$$NFV = TQH - CST \qquad \textit{(Equation 3)}$$

with CST total costs of collection / production, excluding cost of family labour. Costs were estimated based on all monetary inputs going into the harvesting and use of each provisioning service of the wetland. Tools used for harvesting resources represent the main source of cost. The cost of implements was calculated using straight line depreciation. Costs of implements at time of purchase were corrected for inflation using rates from Statistics South Africa (Statistics South Africa, 2006) , and then further divided by average length of use suggested during focus group discussions, and number of uses (for implement used in multiple activities and as indicated by households during the survey). The cost of family labour was not taken into account as the opportunity cost was considered minimal in a context of high unemployment and low earning skills. Because of the frequent presence of associated crops on the same plot (e.g., maize + pumpkins) it was not possible to distribute the costs of cropping activities (land preparation, weeding, post-harvesting etc) to the different crops. Hence the total cost was divided by the number of crops cultivated for each season.

Finally, the Cash Income (*CI*) is the monetary value of quantity sold:

$$CI = QSD \times P \qquad \textit{(Equation 4)}$$

where *QSD* is the total quantity of product sold. It was estimated using the same method as for *TQH*.

Key assumptions and uncertainty analysis

In calculating the economic value of each of the wetland provisioning services, the following assumptions were made, which could lead to a certain level of uncertainty in the result:

- *Assumptions related to quantity of goods harvested*: average quantity collected per time period (i.e. week) were sought from households and were then extrapolated to the whole period of collection within the year to calculate the

Total Quantity Harvested (TQH). However, as quantity collected varies over time, this assumption may generate some uncertainty in particular for uses that take place over a long period throughout the year.

- *Assumptions related to number of households*: due to uncertainties in the actual number of households in the study area, TQH is calculated for a range of households, varying between 377 and 412. The median value of 394 is taken for calculations presented in tables 1 to 3. Uncertainty generated by this assumption applies to all wetland uses except cropping for which the exact number of Participating Households (PHH) is known (i.e. 99).
- *Assumptions due to extrapolation*: This is the classic uncertainty derived from extrapolation of figures estimated from a sample of 66 households. The use of random sampling and the high sampling rate ensures that these uncertainties are minimized.
- *Assumptions related to prices of goods*: Although prices of some products are dynamic and vary over the year, for the sake of simplicity, average values have been used in calculations. However, for some products minimum and maximum prices were collected and minimum and maximum values computed. This will be further presented in the uncertainty analysis.

Proper communication of the level of uncertainty of scientific studies is important. Uncertainty in economic values was expressed quantitatively with a margin of the associated mean error (see Table 4). The Coefficient of Variation (CoV) is used to express the magnitude of uncertainty in value estimates for each service (Sluijs *et al.*, 2005).

4. Results

4.1. Services provided by Ga-Mampa wetland

The provisioning services of Ga-Mampa wetland are its use for crop cultivation, livestock grazing, reed collection (building material), sedge collection (art and craft material), fishing, hunting, fuel-wood collection, edible plant collection, medicinal plant collection and collection of water for drinking, washing and bathing.

All households in Ga-Mampa valley used the wetland for one purpose or another in the year under study. Relative to past years, the use of the wetland during 2005-2006 season for provisioning services is decreasing. For example, all respondents agree to have collected edible plants from the wetland prior to 2005-2006 cropping season, however only about 95% collected them during the 2005/2006 session (Figure 3). For uses such as fuel-wood, water collection, fishing and hunting, households voluntarily decided not to use these services, mainly because they have access to alternative and better endowed sources for these products. However, for services such as sedge and reed for which there is no alternative source in the area, the absence of use of the wetland is due to the decreasing availability of these resources, which can be closely linked to the encroachment of agriculture into the wetland.

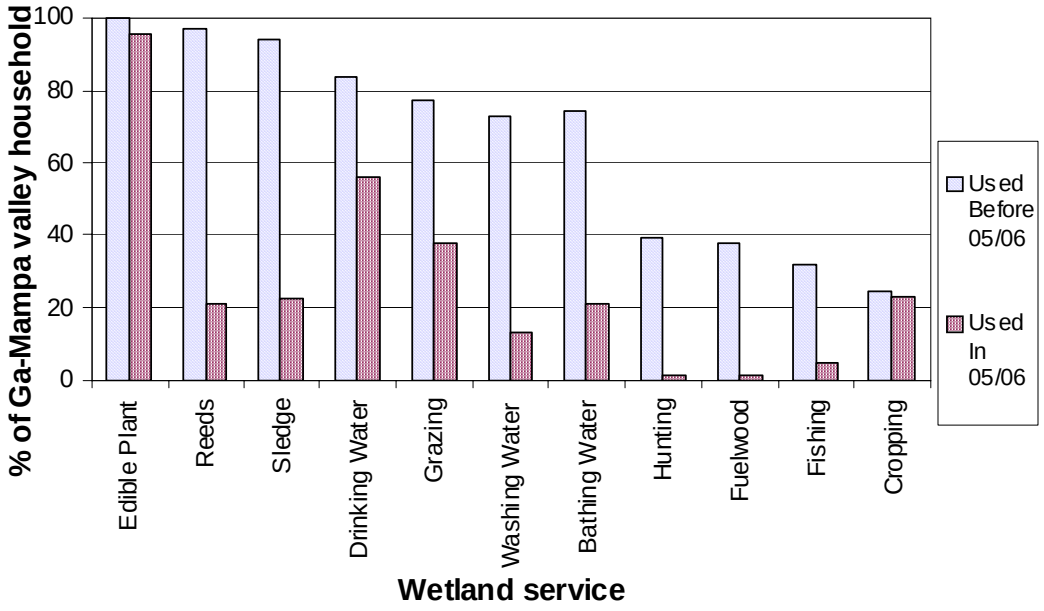


Figure 3: Proportion of households using the wetland before and during 2005/2006 season for each wetland service (from field survey, 2006)

4.2. Use value of wetland provisioning services

Table 1 presents the net financial value, time spent per household and value per unit of time of the main provisioning services of Ga-Mampa wetland. Table 2 details the number of households involved in each crop, the quantities collected and values of main wetland crops in Ga-Mampa valley, while Table 3 presents similar information for other wetland services.

Table 1: Net financial value, time spent per household and value per unit of time of the main provisioning services of Ga-Mampa wetland

Wetland services	NFV per participating household (US$)	NFV per hectare (US$) (*)	Time spent per participating household (hours per year)	Value per hour spent in the activity
Cropping	1072	263	942h	R8.2/h
Edible plant collection	84	263	91h	R6.0/h
Reed collection	93	65	41 h	R14.6/h
Sedge collection and mat making	88	66	80 h	R8.9/h
Fuel wood collection	667	33	108h	R40.0/h
Hunting	49	2	10 h	R31.5/h
Fishing	12	2	-	-

(*) based on total wetland area.

- ***Edible plant collection***

Edible plant collection is the most frequent wetland provisioning service, as at least 95% of households collect edible plant from the wetland. Collection takes place all year round with highest collection intensity between November and March. Some households collect excess of these plants in the wet season and sun-dry them for use in the dry season when available quantity in the wetland is reduced. Collection is done by hand into small farm seed buckets. During the survey, the buckets were used as unit of measurement since it was easier for respondents to estimate quantity using this unit. A 2*kg* bucket was estimated to contain about 300g of edible plants; analysis was based on this conversion.

At average price of R2 ($0.31) per 150g, annual gross value of edible plants collection from the Ga-Mampa wetland is $31,523. Because cost of collection is due only to the farm seed bucket whose cost is regarded as negligible, NFV for edible plant was estimated equal to GFV. 86% of harvested edible plants is used for direct household consumption, while some 11% is used to meet social responsibilities through gift giving to elderly neighbours and relatives. Participating households spend on average about 91hours annually collecting edible plants, hence a value of time spent on this activity of about R6 ($0.93) per hour.

- ***Cropping***

Only about 25% of households in Ga-Mampa valley have permitted access to use of the wetland for cropping purpose (Figure 3). As the wetland falls under communal land, permission to access it for cultivation is usually given by the headmen. Presently, there are no more available plots and even if there are, authorization is no more being given. Based on field study, it was estimated that about 66 hectares (ha) of the wetland is under cultivation. Average size of plot in the wetland is 0.66ha per wetland cropping household.

The main crops cultivated in the wetland during the wet season (October–April) are maize *(mabele* - Pedi names used by local people are indicated in brackets*)* which is often intercropped with vegetables *(morogo)* and groundnut *(dimake)* (the secretary of the community development forum indicated they do this to help preserve soil moisture). Coriander (*mospo*) and beans are popular dry season crops. Sugar-cane *(moba)* and banana are the most common permanent crops in the wetland. Other crops mentioned to be cultivated in the wetland include spinach, cabbage, tomatoes, onions, pumpkins and beet-root.

Crop production yields an estimated annual gross value of $36,788 (Table 1). About 94% of this is generated during the wet season. However, only 57% of the cash income from cropping is generated during this season, because only a small proportion of maize, the main crop during the wet season, is sold, whereas dry season crops are more often marketed (groundnut, coriander, beans, beetroot, sugarcane and banana). Value of time spent on cropping was estimated at R8.2 ($1.27) which is comparable to average hourly wage in Ga-Mampa valley (R8, $1.24) (Table 3).

- ***Reed collection***

As in many other wetlands in Africa, Ga-Mampa people collect reeds *(Phragmites mauritianus)* for roofing their houses. Most respondents believe that use of reeds in buildings has been gradually declining in Ga-Mampa valley, a condition blamed on decreasing quantity of reeds in the wetland coupled with “modernization” leading to taste for zinc roofing. Approximately, about 50% of buildings in Ga-Mampa are roofed with reeds probably collected in Ga-Mampa wetland. Period to collect reeds (usually between June and July) is

sanctioned by the headmen. It is an offence to collect reeds without the headmen's permission when they have not yet declared time for reed collection.

Annual reed harvest is estimated at 2,526 bundles. Reed and sedge are harvested in bundles. A bundle is about 60cm in diameter and could weight between 5 and 10kg. Of this about 72% is used directly by households for roofing their own house. Estimated gross value of reed collection in the Ga-Mampa wetland is $7,820. Apart from labour, the main cost involved in the use of reeds is mainly due to cutlass used for harvesting.

- ***Sedge collection***

Sedge *(Cyperus latifolis* and *Cyperus sexangularis)* is an important wetland resource in Ga-Mampa as in many other wetlands in Africa. Sedges are used for making different art and craft items such as baskets and mats (*legoga)*. Sedge collection is regulated by headmen in the same way as reeds with regards to period of collection. Sedges are hardly sold until *legoga* is made from it.

An estimated 756 bundles of sedges are harvested from the wetland annually. Of the total quantity harvested 75% (564 bundles) is used in making mats and the remaining 25% (192 bundles) is sold, mainly to households within Ga-Mampa. It can be assumed that they were used for making mats, however because this was not investigated during the field work, this assumption has not been considered in the calculation. On average, 0.75 bundle of sedge, is used to make one mat, meaning in total, about 750 mats were made annually. Of this total, 77% were sold to customers from Ga-Mampa, Kappa and Mafefe. The remaining was used as gift and for personal use. Combining worth of quantity sold directly in bundles at R20 ($3.10) per bundle, and number of mats made at a standard price of R80 ($12.4), average annual GFV derived from sedge harvesting from the Ga-Mampa wetland is estimated as $9,288. Cost involved in use of sedge from the wetland is due to (i) cutlass used for harvesting (ii) thread and needle used in making mats (iii) cost of building a locally made knitting machine, and (iv) cost of transportation to and from market. Taking these monetary costs into consideration, average annual NFV was estimated as $7,918. Cash income derived from sales of bundles of sedges and mats amounts to $7,728.

It takes about twenty hours (3 hours for walking to and from wetland and 17 hours for harvesting) of household labour to collect average quantity of sedge (8.4 bundles), in addition, it requires about 7.2 hours to make 1 mat. The value of time spent in this activity is then estimated at R8.9 ($1.38) per hour.

- ***Hunting***

Hunting is also not a major use of the wetland, as only an estimated 1.5% of households hunt from the wetland. Moreover, this seems to be a collection by chance and not a deliberate action. On the other hand, most households deliberately go hunting in the mountains. There is no market for game in Ga-Mampa valley. PHH and members of focus group discussion suggest chicken as the closest substitute for the game. It is believed that an average game of about 3kg is worth about R31.5 ($5). Annual GFV of hunting in the Ga-Mampa wetland was estimated at $4,012. Game was collected using dogs to hunt them down, cost was thus considered insignificant as such GFV=NFV.

Table 2: Participating households, quantities collected and values of main crops cultivated in Ga-Mampa wetland

Crops	Total number of participating households (1)	Average quantity harvested per participating household (2)	Total area (ha)	Yield per ha	Total harvested (3)	Unit	% sold	Unit price in Rands (in US$) (4)	Gross financial value (US$) (5)	Net financial value (US$) (6)	Cash income (US$) (7)
Maize	90	1222	56.3	1960	110010	kg	5.2%	1.79 (0.3)	30474	25687	1584
Vegetable (*)	57	28	*		1584	kg	0.0%	13.33 (2.1)	3269	3181	0(**)
Ground-nut	8	213	2.2	774.5	1704	kg	88.0%	2.69 (0.4)	709	660	619
Sugar cane	6	125	0.4	1875	750	sticks	72.0%	1.00 (0.2)	116	74	84
Banana	3	50	0.4	375	150	bunches	60.0%	12.50 (1.9)	290	235	174
Coriander	3	960	1.9	1516	2880	kg	67.0%	2.69 (0.4)	1198	1150	799
Beans	3	280	2.3	365	840	kg	86.0%	4.69 (0.7)	610	444	522
Beetroot	3	150			450	kg	40.0%	1.75 (0.3)	122	79	49
Total crops									36788	31511	3831
Per household									93	80	10

(*) Intercropped with maize

(**) None of the planted vegetable was sold, however, standard price of vegetable in Ga-Mampa valley is R13.33/kg.

(1) estimated from proportion of participating households in the sample and total household number in the population.

(2) estimated from surveyed households

(3) computed from average quantity harvested per participating household and total number of participating households

(4) Unit prices were estimated from household survey and observation in local markets. Rands prices were converted to US$ using an exchange rate of R6.46 for US$1 (Statistics South Africa).

(5) Gross financial value is the economic worth of total quantity harvested.

(6) net financial value is GFV less cost of harvesting. Here GFV and NFV are almost equal because most uses often require little or no cost to households.

(7) Cash income is the economic worth of quantity sold.

Table 3: Participating households, quantities collected and values of main wetland provisioning services in Ga-Mampa valley (excluding crops -see Table 2)

Material harvested	Total number of participating households (1)	Total harvested or produced (2)	Average quantity collected per participating household (3)	Unit	% sold	Price per unit in Rands (US$) (4)	Gross financial value (US$) (5)	Net financial value (US$) (6)	Cash income (US$) (7)
Edible plants (Morogo)	376	15273	41	kg	2.8	13.0 (2.0)	31523	31523	883
Building material (reeds)	84	2526	30	bundle	18.8	20.0(3.1)	7820	7795	1467
Art and craft material (sedge)	90	756	8.4	bundle	25.4	20.0 (3.1)	594	-	594
		750		mats	76.8	80.0 (12.4)	9288	7918	7133
							9882	7918	7728
Fuel wood	6	1296	216	bundle	0.0	20.0 (3.1)	4012	4003	0
Hunting	6	60	10	piece	0.0	31.5 (4.9)	293	293	0
Fishing	6	708	39	piece	0.0	2.25 (0.3)	247	221	0
Total natural resources							53777	51753	10078
Per household							136	131	26
Total cropping							36788	31511	3831
Total wetland service							90565	83263	13909
Total per household							230	211	35

(1) estimated from proportion of participating households in the sample and total household number in the population.
(2) computed from average quantity harvested per participating household and total number of participating households
(3) estimated from surveyed households
(4) Unit prices were estimated from household survey and observation in local markets. Rands prices were converted to US$ using an exchange rate of R6.46 for US$1 (Statistics South Africa)
(5) Gross financial value is the economic worth of total quantity harvested.
(6) Net financial value is GFV less cost of harvesting. Here GFV and NFV are almost equal because most uses often require little or no cost to households.
(7) Cash income is the economic worth of quantity sold.

- ***Fuelwood***

Fuel-wood collection in the wetland is very limited. This is probably due to the wetness of fuel-wood from the wetland and the availability of drier ones in the surrounding mountains and other parts of the Ga-Mampa valley. Reported cases of fuel-wood collection from the wetland were only in the dry season. Fuel-wood is collected in bundles, which could measure up to 70cm in diameter and about 200cm long with an approximate weight of 10-15kg.

An estimated annual harvest of 1,296 bundles of fuel wood is reportedly collected from the Ga-Mampa wetland. Though no data exist on sale of fuel-wood from the wetland, standard price for fuel-wood (collected from other sources) in Ga-Mampa valley was R20 ($3) per bundle. Thus GFV for fuel-wood is estimated as $4,012. The only cost involved in fuel wood harvesting is cost of axe. NFV is therefore estimated at $4,003.

- ***Fishing***

In this study the Mohlapitsi River was delineated and not considered as part of the wetland, hence fishing activities going on in the river were not regarded as wetland activities. Only households with cropping plots in the wetland reported fishing from the wetland. It was not possible during this study to determine the different species of fish available in the wetland. All fishes collected were used for household consumption.

An average sized fish of about 100g weight is worth R2.25 ($0.3). Estimates reveal that a total annual harvest of 708 averagely sized fish is caught from the Ga-Mampa wetland annually. This gives an annual gross financial value of $247; cost is associated with buying hooks and thread giving an annual NFV of $221. It was not possible to estimate time spent fishing.

- ***Water collection***

Wetland water is mainly used for washing, bathing and drinking. Other uses of wetland water are for watering domestic animals and building purpose. Only households from Manthlane village deliberately go to the wetland to collect water. For households from other settlements water collection in the wetland is associated with other activities, such as cropping or edible plant collection. In these other villages, the main sources of water for domestic uses are the numerous springs and streams located at the bottom of the mountains, and closer to the settlements than the wetland. However, virtually the entire population has collected water from the wetland in the past.

In all it is estimated that about 1,288 kilolitres (kl) of water is drawn annually from the wetland. This represents about 418kl for bathing; 186kl for washing; 583kl for drinking; 101kl for other purposes. Valuing the monetary benefit from water collection in Ga-Mampa valley presents two main difficulties, (i) generally, in South Africa, there is no price for water in this kind of rural areas with very low level of water services (Lefebvre *et al.*, 2005) (ii) even in the absence of this price, substitutes are available to wetland water and these alternatives require even less travel time. Thus, economic value of water is not included in this study. On the basis of a daily consumption ranging from 29 litres (consumption from municipal network estimated by DWAF, 2003) and 50 litres per person (suggested by Gleick, 1996 as a minimal water requirement) only 2.6% to

4.5% of total water requirement of the inhabitants of Ga-Mampa valley is collected from the wetland.

- ***Livestock grazing***

It is estimated that approximately 70% of households in Ga-Mampa valley own at least a type of livestock (cows, donkeys and goats). However, only an estimated 38% of entire households in Ga-Mampa valley could ascertain that their livestock does depend on the wetland for forage. Generally, data on grazing benefit from the wetland was difficult to acquire, because people pay less direct attention to the activities of their livestock. Because of lack of adequate data and high uncertainty, the economic value of livestock grazing is not included in the present economic analysis.

- ***Medicinal plant collection***

Not much is known about the use of the Ga-Mampa wetland for medicinal plants. This is probably due to "secrecy" in the community about its use (Darradi, 2005). Information gathered reveals that, three main medicinal plants are collected from the wetland: *Mupurogu*, *Mutusa*, *Masheo Mabe.* Unfortunately it was not possible to determine the scientific name of these plants during the field survey. *Mupurogu,* is claimed by one of the users to be able to "prevent any type of disease, no matter how bad it could be". *Mutusa* and *Masheo Mabe* are used together with other plants collected from elsewhere (mountain) for local male fertility drug. Because of the seeming secret surrounding its use it was not possible to estimate the economic value of medicinal plant in this study.

4.3. Total use value of main provisioning services

Based on the calculation of the economic value of each individual provisioning service of Ga-Mampa wetland (section 4.2), the total economic value of all provisioning services provided by Ga-Mampa wetland was estimated at 90.565 US$ (gross financial value) (Table 2). Based on this estimation, cropping contribute the highest value of about 40% of the total gross financial value of the Ga-Mampa wetland. If we look at cash income, however, sedge collection accounted for about 56%.

During the second focus group discussion respondents ranked the value of wetland services, using a pebble distribution method. This was weighed (as a percentage) and is used as the perceived livelihood value of the wetland by local people. Comparing the weight of empirically estimated economic values of each wetland service with the weight of the perceived livelihood value put on them by respondents (Figure 4) shows that, except for reed collection, the relative importance of services perceived by people is closer to their relative weight in gross financial terms than in cash income ones, meaning that people integrate in their valuation the part of services self-consumed by households. For example, cropping was perceived as being most important by the stakeholders but our analysis showed that in reality cash income from sedge-harvesting for handicraft use was twice as high. However, this comparison should be made with great caution, as the metric used in both cases is not the same and composition of the focus group, even if it reflects the general diversity of wetland users is not statistically representative of the population, contrary to the sample.

In reality, it is extremely difficult to estimate an exact economic value for wetland services due to uncertainties on many data. Using minimum, average and maximum values for prices and quantities of each service, it was possible to estimate range of values. Estimates suggest that values for edible plant collection attract the highest level of uncertainty (Table 4).

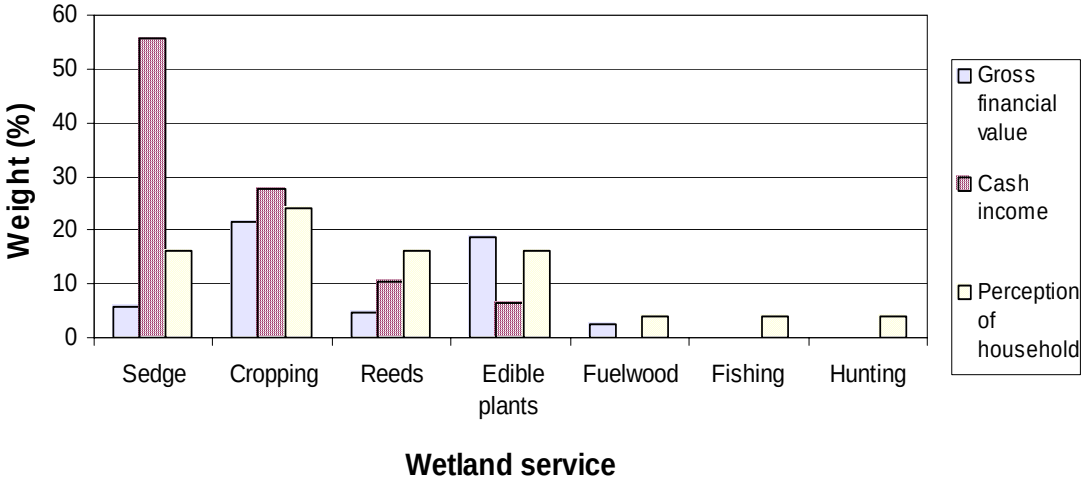


Figure 4: **Relative importance of economic value of wetland services (GFV and CIC in percentage of total wetland economic value) compared with their relative value as perceived by stakeholders (from field survey 2006)**

Table 4: Uncertainty associated with estimated economic value of main provisioning services

Wetland service	Gross Financial Value		Cash Income	
	Value (Mean ± MD)	CoV	Value (Mean ± MD)	CoV
Cropping	36788 ± 2168	10.21	3831 ± 182	8.23
Edible Plant	31523 ± 5387	29.33	883 ± 149	29.06
Reeds	7820 ± 189	4.20	1467 ± 35	4.20
Sedge	9882 ± 254	4.44	7728 ± 198	4.44
Fuel-wood	4012	0.00	0	0.00
Hunting	293 ± 19	11.11	0	0.00
Fishing	247 ± 8	5.56	0	0.00
Total USD	90565 ± 8027	10.50	13909 ± 565	7.03

4.4. Contribution to livelihoods and distribution of benefits across households

The household with the highest estimated annual benefit of $2,625 (GFV) uses the wetland for all services except for fishing and hunting. On the other hand, household with the least benefit use the wetland only for edible plant collection having an annual

GFV of $17. This suggests a high variation in value of benefit between households. Assuming benefit is shared equally among the 394 households in the study area, the average wetland's contribution amounts to $230 per household in gross financial value (about 15% of average household total cash income), $211 in net financial value and $35 in cash income to each household in the Ga-Mampa valley.

More than 20% of the total yield of each crop is consumed directly for household subsistence. The proportion of wetland products self-consumed is even higher (over 80%) for maize (main staple meal in Ga-Mampa valley) and edible plants (source of nutrient diversification). The wetland plays also a role in the diet diversification as it allows the cultivation of crops, such as bananas or sugar cane that cannot be found in dryer areas. Pap made from maize is the most common meal in South Africa, eaten almost everyday by each household in the Ga-Mampa valley. With an irrigable area reduced by the poor state of irrigation infrastructure, alternatives to cropping maize in the wetland are limited. Moreover, considering the generally low level of cash income per household, most families cannot afford buying milled maize from the market. Thus, the Ga-Mampa wetland appears to play an important role in the food security of the local population. Average annual maize yield per participating household is 13 bags; this is believed to be adequate for an average household as most households interviewed reported having left-over maize bags with the milling company (after giving un-milled maize to the milling company, households can have milled maize bags back on request).. It is deduced that an average household require approximately a bag of milled maize per month. The total maize requirement for the 394 households would then amount to around 449T of grain. The total production of maize in the valley is evaluated around 348T (with 95% of the 166ha irrigable under maize, with an average yield of 1.5 T/ha, according to Chiron, 2005). Maize produced from the wetland represents therefore 24% of the needs and 31% of the total production in the valley. Apart from use for household consumption some quantities is sold for cash (mostly to the milling company), some other are kept to be used as farm seed for the next cropping season, while another part is given in exchange for farm labour. Interestingly, no household reported giving part of their maize yield for gift.

Apart from serving as a buffer for soil moisture, cultivated vegetable in the wetland is important to household food supply. Over 80% of cultivated vegetables are used directly for household consumption, serving the same purpose as edible plants collected from the wetland; the remainder is given out as gift. Substantial part of other crops cultivated in the wetland is sold for cash, generating a much needed income in a context of low income earning, to meet other household requirements. Part of the vegetable production is used as gift to neighbours and relatives, however, no part of "main" crops cultivated (coriander, groundnut, beans and maize) is used as gift.

The total quantities of fuel wood, fish and game derived from the wetland are used directly in households to support their livelihoods. It is believed that because most households in the Ga-Mampa valley cannot afford frequent buying and consumption of meat, they resort to using edible plants to diversity their meal. Thus, to meet the requirement and the feeling they would have derived from eating meat, local people consider edible plants from the Ga-Mampa wetland as quite important. Based on discussion and field observation (household in whose compound one of the researchers was accommodated) edible plants are consumed in meals at least four days a week,

most of which are collected from the wetland. Some portions of harvested edible plants are used as gift to neighbours and elderly relatives.

Reed collection is equally important and is useful both as a source of income and as source of material for building/roofing their homes. In the absence of reeds from its only source in the Ga-Mampa valley (the wetland), households will resort to buying roofing zincs, which most of these poor households might not be able to afford. Moreover, the roofing zinc will not provide them the coolness they derive from using reeds. It is only for sedge collection that more than 50% of quantities collected are sold to generate household income. This is mainly due to its use in mat making which is a significant income generating activity from the Ga-Mampa wetland.

In Ga-Mampa valley, livestock are kept to support household livelihood. Most end up being sold or consumed during festivities or celebrations. Livestock is not only important when consumed but also provides products such as milk (mostly consumed directly in households, most households do not produce milk on commercial scale) and manure used on farm and as substitute to cement; and as means of transportation and draught power. Through the provision of forage and water, the Ga-Mampa wetland supports the sustenance of these animals, which in-turn enable them to continually provide products which are important for the people.

Whereas there could be alternative locations outside the wetland to conduct activities such as cropping, livestock grazing, fuel-wood collection, fishing and water collection, there are no alternative locations for sedge and reed collection outside the wetland. This might be a problem for households depending on reeds and sedge. For example, households using reeds for building their homes will have to seek substitute in buying roofing zincs from the market; while those selling reeds and/or making mats from sedge will inevitably be loosing a major source of cash income. This means that households in Ga-Mampa could be vulnerable to changes in availability of wetland resources, most especially those for which there is no alternative location for collection in the vicinity. As field data reveal that most of these households have no copping strategy to adjust to changes (reduction) in services, there is possibility this can make them even more vulnerable to poverty.

An analysis of differences in benefits derived from wetland provisioning services across households was conducted. For the purpose of this analysis, provisioning services have been grouped into four categories: cropping; material collection (sedge, reed and edible plant collection) water collection (collection of water for drinking, bathing, washing and for other purposes) and others (fishing, hunting and fuel-wood collection). One can observe that household head age has a significant effect on cash income from material collection, household with a head aged more than 70 deriving more cash income than households with a younger head. Similarly material collection benefit (CIC, NFV, GFV) is significantly impacted by household size: households sized between 11 and 15 tend to get more benefit than households with other size, probably due to their higher manpower. Household location explains variation in benefits of water collection with households from Manthlane benefiting more from water collection than households from other villages. As expected, differences in wetland benefits from cropping can be explained by occupation of head (households who see themselves as farmers get more benefits from cropping than others) and the accessibility to wetland plots. However, only the access to cropping plot has a significant effect on the overall benefit

households derive from the wetland. This is obviously because of the large contribution of cropping to the overall value of the wetland. There was no significant variation in benefit based on gender and educational level of head of household and household income.

5. Discussion

Economic valuation

Economic valuation studies are, by nature, fraught with uncertainties, which often results in value estimates that are crude and inexact (Hermans *et al.*, 2006). The combination of the analytical complexity involved in the valuation process with the complexity caused by the involvement of different stakeholders from varying institutional scales in decision-making processes, explains why a comprehensive, complete and undisputed valuation is virtually impossible to achieve. We agree that economic valuation is useful and "*failure to quantify ecosystem values in commensurate terms with opportunity costs often results in an implicit value of zero being placed on ecosystem services*" (Loomis *et al.*, 2000). In practice, however, it may be better to reach an agreement based on imperfect value estimates rather than continuing theoretical disputes over the "real" value of environmental resources (Hermans *et al.*, 2006).

For this study, the direct market valuation technique was used among the different environmental valuation methodologies discussed in literature (Costanza *et al.*, 1997; de Groot *et al.*, 2002). By construction it can only capture use values of wetland services. It is possible that the use of other techniques (for example contingent valuation or benefit transfer) will result in slightly different results. Since market prices exist for most services in this study (or close substitutes), the use of direct market value is able to give a rather realistic value estimate. Contingent valuation would not have been as precise as direct market valuation on the distribution of values among services; however it would have been useful to estimates non use values of the wetland, assuming that its methodological difficulties can be overcome in this context.

Method of data collection

The main approach to data collection adopted in this study is the questionnaire survey. In addition, focus group discussions, field observations and measurements, key informant interviews, market pricing, and the Pebble Distribution Method were also used to complement and supplement data. The use of research triangulation was found to be essential; it was very helpful in offsetting some expected limitations by providing complementary and supplementary information. For example, some values given by households were cross checked with the extension officer and the secretary of the Ga-Mampa Community Development Forum. Time was a major limiting factor in this research. Especially for data collection, there was only about six months for the entire study, of which less than three months was spent on actual field data collection. A research with field work covering a longer period, allowing for monitoring of household wetland use, will no doubt allow collecting more data and provide better estimates. Interviews were often long, on average about 1.5 hours, taking a toll on respondents. This was not always a problem because respondents were informed more than a week before they were scheduled to be interviewed, and for some respondents interviews were split into two sessions.

The fact that the researcher collected field data personally was very helpful, as it allowed for more probing questions not originally foreseen in the questionnaire. The iterative nature of the study left some flexibility and was essential in positively modifying the study as it progressed to take new information into account. This can be important to a successful valuation study. These facts are in line with suggestions for an integrated wetland research framework made by Turner *et al.*, 2000.

Discussion of results: Comparison with literature

Compared to the number of studies conducted on other continents, there are only a few economic valuation studies of African wetlands (Schuyt, 2005). Yet, this study did find several other empirical studies against which the results generated can be compared. Most existing studies were conducted before 2006 so to make the values comparable they are converted to 2006 values using an annual inflation rate of 3%.

Our study, like most economic valuation studies, underscores the fact that provisioning services provided by wetlands contribute a great deal to the livelihoods of local stakeholders depending on them. In this study, sedge collection contributed the highest economic value to household income which is a divergence from empirical findings in Turpie *et al.*, 1999; Schuyt, 1999 and Turpie, 2000 in which fishing was the most significant wetland service contributor to household income ($224 per household compared to a meagre $1 per household in Ga-Mampa wetland, which is the lowest value of all services). This difference is most probably due to the distinction of the boundaries of the study area; in our study fish caught from the adjacent Mohlapitsi River is not regarded as a value of the wetland. The variation could also be due to the type of wetland under study. The Turpie *et al.*, 1999 study included large lakes and floodplains of large rivers with a high potential in fish production, which is obviously not the case for the Mohlapitsi River, as most of the wetland is not flooded throughout the year.

Cropping contributes significantly to the total value of Ga-Mampa wetland, as is the case in most of the studies reviewed. In Ga-Mampa wetland, the value of cropping per household is estimated at $93, compared to $3 per household for Nakivubo urban wetland, Uganda (Emerton *et al.*, 1999); $109 per household in Barotse; and $363 in Lower Shire (Turpie *et al.*, 1999). The low value from Nakivubo could be due to the fact that less than 2% of households were involved in cropping against about 25% in Ga-Mampa valley. The net value for material collection per household (edible plants, reeds and sedge) in the Zambezi basin ranged between $23 and $159 against an average net value of $120 in Ga-Mampa. The contribution of sedge per household in Ga-Mampa is much higher than that available for households in Nakivubo, i.e. $25 against $0.5.

When values per household from Ga-Mampa wetland are compared with a similarly small wetland such as the Nakivubo urban wetland (529ha), Ga-Mampa community derives relatively more benefits due to the population density per wetland area (0.25ha/household in Ga-Mampa against about 0.02ha/household in Nakivubo). In Ga-Mampa valley, the total contribution of the main provisioning services provided by the wetland per household is estimated at $230 in GFV; $211 in NFV and $35 in CIC. These values are about 60%, 63% and 93% less than values estimated for the Rufiji floodplain and Delta (Turpie, 2000). This is most probably a consequence of the more provisioning services supported by Rufiji floodplain and Delta in relation with the Ga-

Mampa wetland. When per hectare value estimates are compared, the services of the Ga-Mampa wetland yield higher values relative to other studies. For example, the net value of cropping per hectare per year in Ga-Mampa is $263 relative to about $128 in Nakivobo Urban Wetland in Uganda. All values from the present study fall well within the range of suggested values in De Groot *et al.* (2002), i.e. food provision can range between $6-2761 per ha/ year.

6. Conclusion

This study collected original field data which provided valuable information, showing that the direct use value of the main provisioning services of the Ga-Mampa wetland (1 km^2) is worth about $90,000 per year (2005/2006 values). It shows that it is possible to collect good quality data needed for economic valuation in a relatively limited amount of time (approximately 6 months). It is important for the quality of data to combine different data collection techniques and to closely monitor the administration of the household survey.

One of the original aspects of this study is that it applies to a small wetland, unlike similar studies in Southern Africa, which generally focussed on larger wetlands. It shows that smaller wetlands are also very essential to sustaining the livelihoods of the local stakeholders. This information might prove very useful for decision-makers and local stakeholders in the development of a management plan for wetlands similar to Ga-Mampa wetland.

The repetition of this kind of exercise in other small wetlands would show whether the methodology used in the present study can be reproduced or not and if results are comparable. It would then be possible to conclude on the comparative advantages of direct valuation and benefit transfer for this kind of wetlands in terms of cost, time and data requirements and reliability of estimated values. It would also be interesting to systematize the comparison of market valuation techniques with participatory stated preference techniques (like the pebble distribution method in focus group discussion) in order to better understand the importance of wetland services to people's livelihoods and elicit the most relevant criteria to measure economic value.

Information generated from this study will be integrated into the overall Challenge Program Water and Food research project in the Limpopo basin and will be an essential input into the trade-off analysis and subsequent development of a management plan for the Ga-Mampa wetland. In particular, the dynamic model currently developed to analyse trade-offs among Ga-Mampa wetland services and support decision-making about its management will benefit greatly from this study.

The analysis of trade-offs between wetland services requires an evaluation of other services provided by the wetland (regulating services and cultural services), which was beyond the scope of the present study. This implies a better understanding of the bio-physical functioning of the wetland. An on-going hydrological study and the running of the above-mentioned dynamic model will help to draw conclusions regarding the sustainability of present wetland use levels. In the meantime, local stakeholders urgently need support to identify alternative sources of livelihoods while simultaneously developing sustainable management strategies for the Ga-Mampa wetland.

7. Acknowledgments

This paper is based on the research conducted by Olalekan Adekola in fulfilment of his Master degree with the Environmental Systems Analysis Group, Wageningen University (The Netherlands). It was conducted under the research project *"Wetlands-based livelihoods in the Limpopo basin: balancing social welfare and environmental security"*, which associates National Agricultural Research Institutions from Zimbabwe, Mozambique and South Africa (University of Zimbabwe, University Eduardo Mondhlane, University of Pretoria, Witwatersrand and Limpopo), French research institutions (Cemagref, IRD, Cirad), and the International Water Management Institute (IWMI). The authors are grateful to the people of Ga-Mampa and Manthlane for their cooperation, giving their time and useful insights on the use of the Ga-Mampa wetland. This research received financial support from the Challenge Program Water and Food and the Fonds de Solidarité Prioritaire Echel-Eau of the French Ministry of Foreign Affairs.

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